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AUTOMATED UNIVERSAL HYGIENIC FOOD PROCESSING MACHINE

N DINESH KUMAR[1], CHINTAM V B ADITYA KUMAR[2], E SWETHA[3] & P. ANIRUDH SRINIVAS[4]

[1,2]Associate Professor, Department of Electronics & Instrumentation Engineering, Vignan Institute of Technology & Science, Deshmukhi, Nalgonda(D), Andhra Pradesh, India

[3,4]UG Student, Department of Electronics & Instrumentation Engineering, Vignan Institute of Technology & Science, Deshmukhi, Nalgonda(D), Andhra Pradesh, India

ABSTRACT

The aim of this paper is to evaluate the advantages of Low Cost Industrial Automation such as repeatability, tighter quality control, waste reduction and Integration with business system, Increased productivity and Reduction of labor in the small scale sector in one of the largest countries by population and the fastest growing economy, India. The application of Low Cost Automation (LCA), particularly in small scale industries with simple usage of devices like pneumatic, hydraulic actuators with electrical control to the existing conventional methods will make the automation at low cost to yield higher productivity. This paper was taken up with a view to improve the present system of food process using PLC with low cost automation technique. The main objective of this paper is to show the reduction of manual work, increase the throughput and maintain a hygienic environment with same taste as made by the manual process. It is Very much useful for food industry ranging from small to star hotels.

KEYWORDS: Ladder Network, LCA, Payback Period, PLC, Step-7

INTRODUCTION

In the recent past, Automation techniques have become one of the effective strategies in the modern manufacturing process. Most of the manual operations involved in the production are being automated to get multifarious benefits. It has therefore become imperative for the firms to get themselves equipped with automation systems to meet the growing demand of goods. With the advent of globalization and liberalization, it is necessary that industries explore methods of enhancing automation and thereby increase the productivity to acquire greater competitiveness in the market.

The existing automation systems are to be redesigned to get preciseness and accuracy in their operations. The preciseness and accuracy of the automation system are achieved through its controller. A better controller always enhances the quality in its operations.

Our paper utilizes the concepts of Low cost automation for its implementation. This main aim of the project is to improve the present method of manual cooking, by implementing pneumatics and electronics to attain automation of the required mechanism.

DESIGN OBJECTIVE

The main objective of this paper is to show the reduction of manual work, increase the throughput and maintain a hygienic environment with same taste as made by the manual process. Depending upon the rules and regulations lay down by the Hygienic food process, design can be altered according to the requirements at any time using PLCs. In order to design a solution for a problem related to automation, it is imperative for an Engineer to begin it by defining the Control task, that is, to determine what it needs to be done.

Present Conventional Method

The conventional method of cooking is non hygienic and requires a lot of man power. Staring from vegetables washing/ slicing to rinsing of rice a person has to be involved at each and every step of cooking process. We are not assured of same taste and hygienic levels in manual cooking process. Currently there exists no such automated system which meets the requirements of the organization and quality management. Individual modules do exists in the organization but none of these systems meets all the requirements of the proposed system.

Proposed Method

The drawbacks listed in the present conventional method are overcome in the proposed method. The complete process has to be carried out at predefined time under perfect hygiene conditions. All the vegetables should be washed sliced and have to be mixed with the ingredients along with the oil at exact time in required proportion to get vegetable curries. If the same process has to be carried out for meat items, instead of vegetables meat can be used as the product. Rice should be washed and cooked for the predefined time to get plain boiled rice.

If required the above two processes can be carried out in sequence to get different variety of rice items. The PLC strategy implementations for a control task closely follow the development of an algorithm and produce the solution in a finite number of steps.

HARDWARE AND SOFTWARE

The Block diagram in figure 1 describes the proposed automated food process.

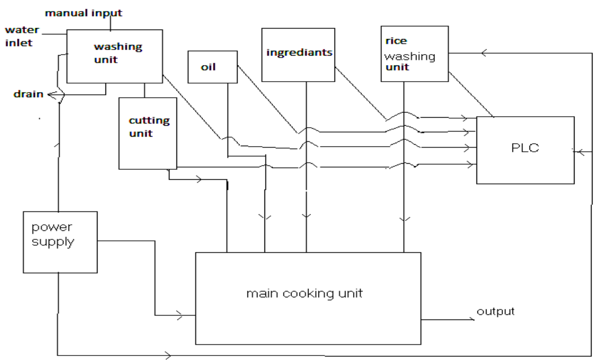


Figure 1: Block Diagram

After deciding the efficient sequence of operations for suggested method, the appropriate actuators and sensors are chosen. All the sensors, actuators and other apparatus required for the connections have been taken for the simulation of input/output modules of PLC. By giving the power supply to the PLC, the program is transferred from computer to PLC after final verification by using **step-7 software**.

Hardware

The hardware like actuators and valves are used in the fallowing units are : Washing unit, Cutting unit, Rice washing unit, Oil storage unit, Cooking unit

Mechanical Design

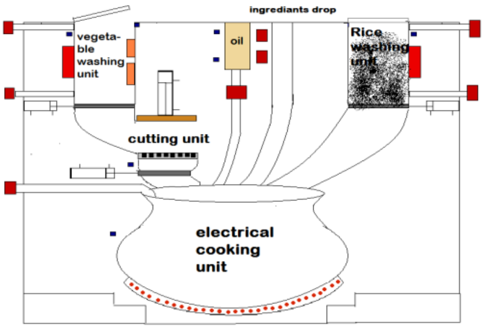


Figure 2: Mechanical Design

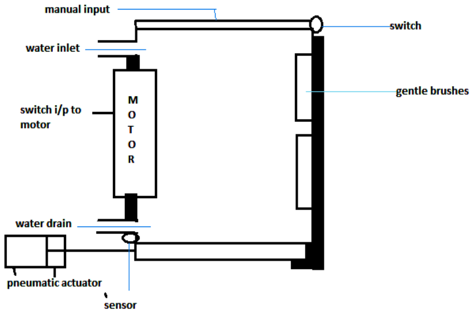


Figure 3: Washing Unit

The above figure shows the mechanical design with all the blocks and the actuators and valves ,Washing unit, Cutting unit, Rice washing unit, Oil storage unit, Cooking unit.

Washing Unit

This unit consists of motor, level sensors, actuator (A), brushes. First the water will be given through the inlet and as soon as the sensor detects the level the valve gets turn off. Then the manual input (i.e vegetables) is given and the door is closed. Then the motor runs for the prescribed time making a squirrel movement of the water and the vegetables gets rubbed against the gentle fiber brushes placed on the wall structure and get cleaned. After that the water will be drained then followed by the moment of the actuator A to retracted position making the vegetables to fall to the next cutting unit.

Vegetable Cutting Unit

This consists of two actuators (B & C) and IR Sensors (2 & 3). The mechanical arrangement is shown in the figure 4.

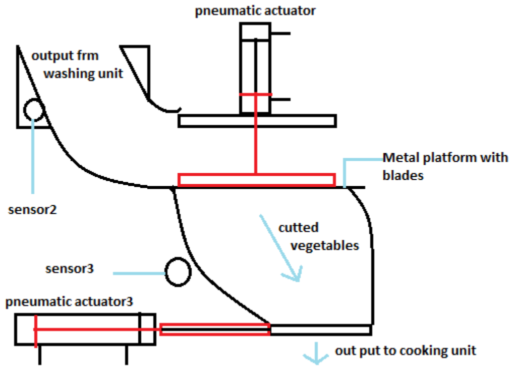


Figure 4: Cutting Unit

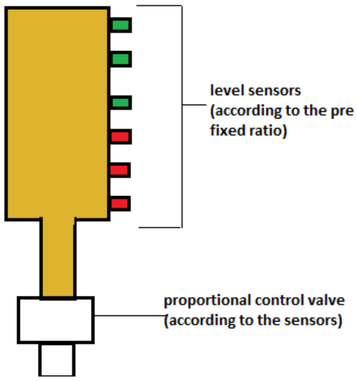


Figure 5: Oil Storage Unit

In this unit the vegetables from the washing unit gets on to the metal blades platform and the sensor activated which makes the actuator to move to forward position smashing the vegetables in a single hit, the sensor senses the sliced vegetables then the actuator C gets into retracted position making the pieces to fall in to the cooking unit.

Oil Storage Unit

The level sensors are placed according to the prefixed ratio by setting them the required amount of oil can be placed into the cooking unit.

Rice Washing Unit

The working and the construction is same as the vegetable washing unit only difference is the timing and the number of times it has to rinse.

Main Cooking Unit

This is an electrical cooking unit in which the heat is produced with the inductor coils or thermostats. This unit will be on as soon as the sensors of the above units issue a triggering signal or if a user wants to run the cooking unit manually, can run by selecting different mode of operations on the user interfacing panel. The size of the cooking unit depends on the quantity needed.

Plc Input & Output Specifications

Inputs& outputs used in PLC for the proposed design are listed in table 1.

Table 1: I/O Specifications

INPUTS	
START BUTTON(S/B)	I 124.0
S1	I124.1
S2	I124.2
Sb	I124.3
Sc	I 124.4
SO1	I124.5
SO2	I124.6
Reset	I124.7
OUTPUTS	
M1	Q125.3
M2	Q125.2
Valve0	Q124.2
A-	Q124.3
B+	Q124.4
C-	Q124.5
Oil Valve	Q124.6
LED1	Q124.7
LED2	Q125.0
D-	Q125.1

Algorithm & Flow Chart

- Start the process (Switch ON the Start button).
- Check the initial conditions
  - All the motors OFF
  - Two drain valves OFF
  - Actuators positions (A+,B-,C+,D+)
  - Oil valve OFF, Main cooking unit ON(Inductor coils)
  - LEDs OFF
- Valve 0,1 in ON position
- Check the sensors SV,SR if yes turn OFF the valves 0,1 if no back to step3.

- Turn ON the MOTOR2, Check the sensor S1 if yes turn ON the MOTOR 1.
- Check the timers T0, T1, If yes turn OFF the MOTORS M1,M2.
- Turn ON the drain valves D1,D2.

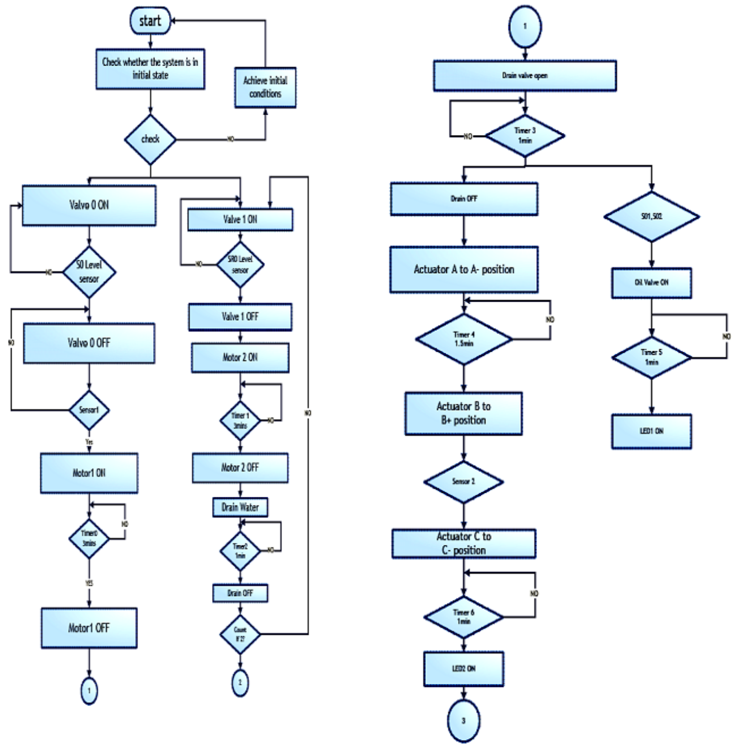


Figure 6

- Check the timers T2, T3, if yes turn OFF the drain valves D1, D2. Check the counter C1, if less than 2 then turn ON the valve 1 again.
- Move the actuator A to A- position, Check the sensors S01, S02, if yes turn the Oil valve.
- Check the timers T4, if yes move the actuator B to B+ position, Check the timer T5, if yes ON LED1.
- Check sensor 2, if yes move the actuator C to C- position.
- Check the timer T6, if yes ON LED2.
- Check timer 7, if yes ON the valve 3, check timer 8, if yes move the actuator D to D- position.
- Check the SD sensor, if yes OFF the valve 3,
- After main cooking unit OFF get back to Reset conditions.

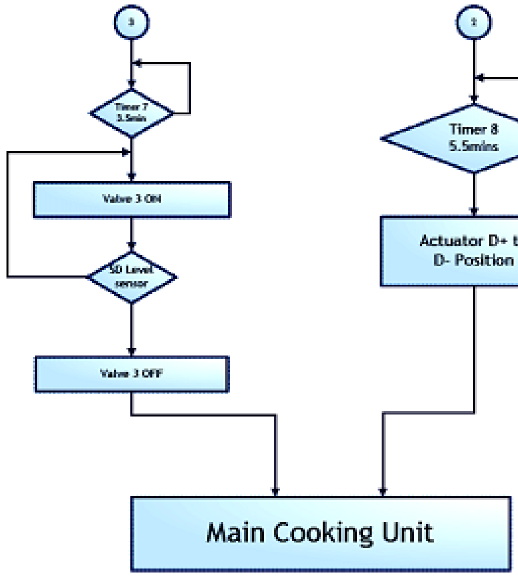


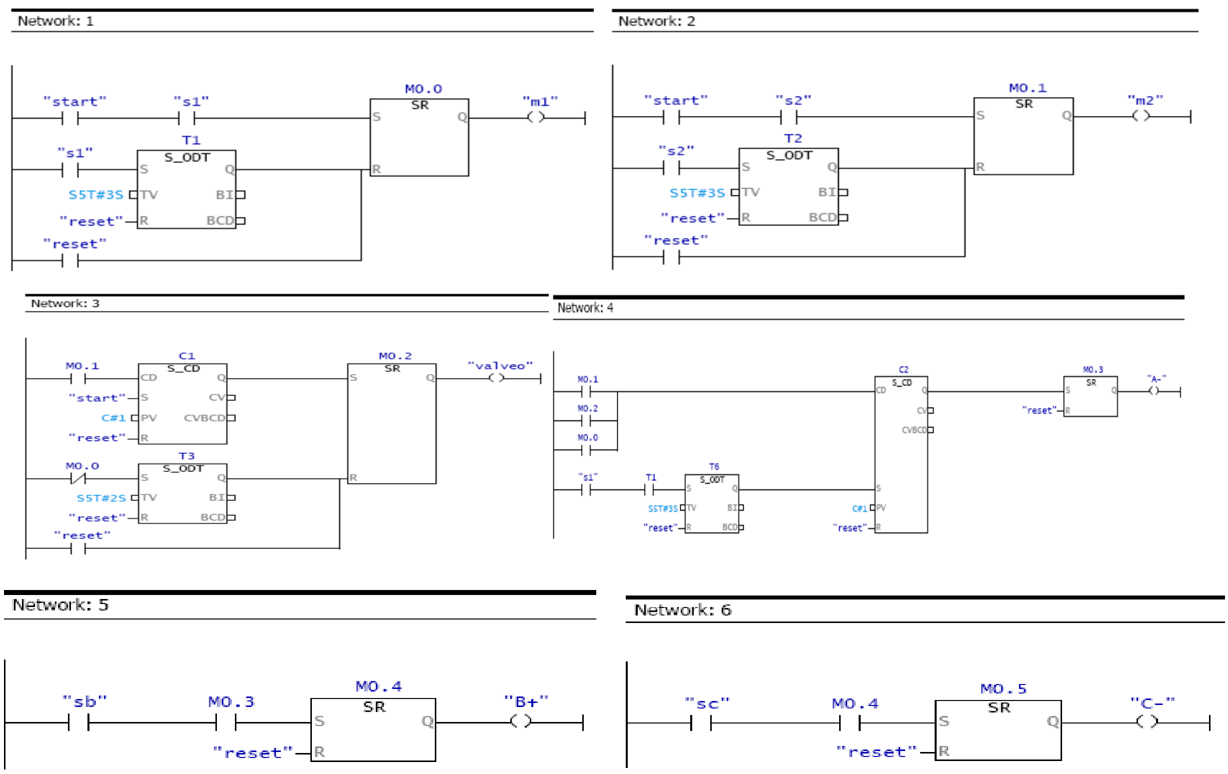
Figure 7

Software

In order to program the Siemens PLC-control series S7-300 and S7-400 efficiently and comfortably the software ***S7 (Step 7) for Windows*** can be used. The complete S7 instruction set is implemented in Ladder Diagram (LAD).

SIMULATION MODEL

The results are shown below using ladder diagrams.



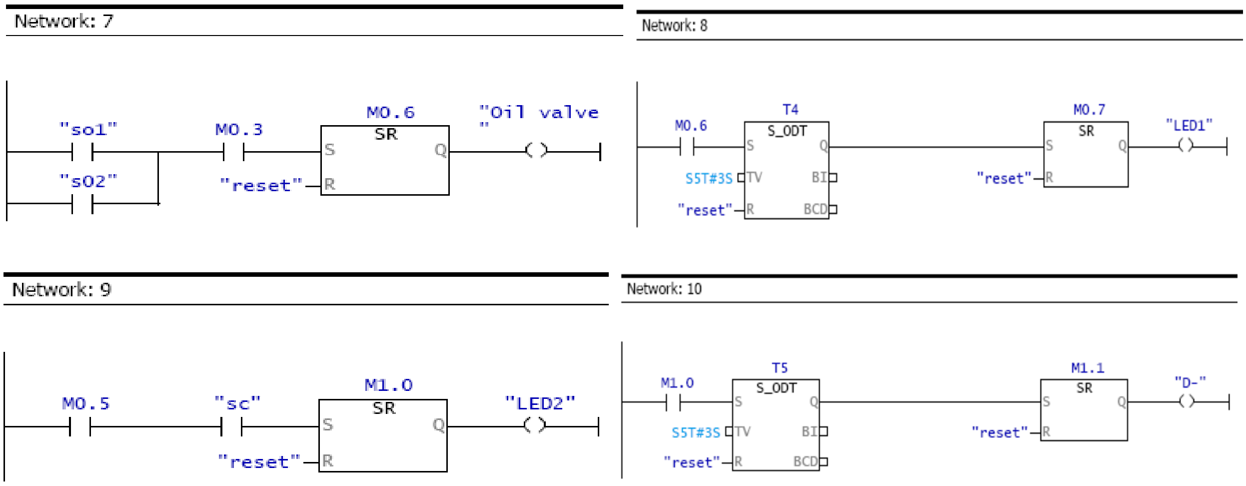


Figure 8

COST ANALYSIS

This analysis gives the estimation of total cost required for the whole unit setup. The costs of various elements used in our project were taken from FESTO SYSTEMS Pvt Ltd., a manufacturing and distributing company. While arriving at payback period, case analysis of small scale restaurant is considered for profit and expenditure financial figures.

Estimated Cost

The costs of various elements used in our project were taken into consideration before arriving at an estimated cost of the unit. Estimated Cost is **Rs.2,94,090**

Estimated Recovery Period

Total Investment (Without Taxes) = Rs.2,94,090

Amount saved on Labor per Month = Rs 2,000*30 = Rs. 60, 000

Total Expenditure per Month on Electrical charges and Maintenance = Rs.30,000

Total profit per month assuming a business of Rs. 10,000 per day = Rs.60,000 (in manual operated process)

Total profit per month assuming a business of Rs. 10,000 per day (in automated operated process)

= Amount saved on Labor per Month - Total Expenditure per Month on Electrical charges and Maintenance

= 60,000 – 30,000

= Rs.30,000 + Total profit per month assuming a business of Rs. 10,000 per day (in manual operated process)

= Rs. 90,000

Depreciation factor (D.F) = 0.15

Pay Back Period = Total Investment / (Net Profit X **(**1-D.F**)**) = 4 **Months** (approx)

CONCLUSIONS

The experimental results shown and tested are as per the basic requirements of any food industry. A sequence for the given operation has been performed by using pneumatic drives as per the developed circuit. The main consideration is

recovery of invested capital. The application of LCA, particularly in small scale industries with the usage of simple devices like pneumatic and hydraulic actuators with electrical control to the existing conventional methods will make the automation at low cost to yield higher productivity for stability and growth of economy of the nation.

ACKNOWLEDGEMENTS

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